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DISCUSSION

Computational Social Theory

(Evolutionary Models, Saturday, October 15, 2005, 3:15–4:45 p.m.)

Chair and Discussant: *Keven Ruby, The University of Chicago*

Keven Ruby: Hello, I'm Keven Ruby, and I will be trying to keep things on track. We'll begin this session with Saunders-Newton, Axtell, Roszman, and Frank talking about "Can Many 'Littles' Make a 'Much': One Approach for Transforming Underspecified Theory into Agency-oriented Rules and Behaviors."

Can Many "Littles" Make a "Much"? One Approach for Transforming Underspecified Theory into Agency-oriented Rules and Behaviors

Desmond Saunders-Newton: I'm with BAE Systems as well as University of Southern California. I'm joined by my colleague, Aaron Frank, who is also with BAE Systems. Our other collaborators in this particular effort are Rob Axtell, who's at Brookings, and Larry Roszman, who's also at BAE Systems.

Today, we want to focus less on some of the model results, and I'll tell you some reasons why. I want to think a lot about some of the interesting challenges we had with this particular project in terms of attempting to craft this very, very high level systems theory of cultural revolution into an agent-based system and the challenges that were associated with that. I'll tell you how we worked through this particular process and how we can actually think a little bit more effectively about finding a rigorous and more structured way to convert these oftentimes very elegant ways of thinking about the world into basically levels of agency.

[Presentation]

Saunders-Newton: This whole notion of formations, institution formations, and social coherence is interesting because you actually measure this and define the appropriate metrics. That was our goal for the six-month effort. As you can tell, six months is not a long time.

Unidentified Speaker: What do you mean when you say, "Game theory coming soon."

Saunders-Newton: Each of the first, second, and fourth building was actually instantiated in the six months. Game theory was coming soon. We're actually dealing with internal R&D now, but yes, that's correct.

[Presentation Continues]

Saunders-Newton: Thank you very much. Are there any questions?

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Joanna Bryson: I have two short questions. One's very high level. You mentioned why a company like BAE might be interested in this area. Is that why BAE is doing this modeling, so they can sell planes only to stable countries? What's their interest?

Saunders-Newton: No, no, no. I'll give you a short answer and … decide … gives you more detail. For those who know, BAE Systems used to be British Aerospace, and once Maggie Thatcher released them, they started buying up crazy numbers of buildings. My group is actually called the Intelligence Innovation Division. We focus on the various intel communities, and we develop combinations of methodologies and advance computational tools to support their activities. I run the Social Computation and Complexity Directorate. So this is a business line for them, and we're working around that.

Bryson: Okay, great. Now I have a much more specific question. During your talk, you mentioned modeling just the elites. Of course, the problem then is having an emergent to lead and not wanting to get caught. At first, I was going to ask how you're going to have a mechanism for adding in new elites, but then I thought, well, maybe you should just have a pool of candidate elites. For example, the 50 governors, because who would have thought Bill Clinton would have come out of nowhere and become President of America? But it's not from nowhere because he was the governor of a state, right? But you don't normally model every state. And, again, Howard Dean from Vermont has an impact, but although many people have heard of him, that wouldn't necessarily be considered the top elites, right?

Saunders-Newton: Yes. Our initial efforts have been focused more on trying to capture the people we know now, and to the best that we know of, since we support a lot of the work of the intel community. They do track a lot of the emergent elites, so these people have some type of authority. We actually get to start earlier in the process than others may, but your point is well taken. If you were actually doing a totally open-source activity, it may be something of a challenge to capture all these things. You have to be open to it.

Ruby: Any other questions?

Charles Macal: Desmond, you suggested that your approach is based on a data-grounded approach relative to seemingly economic measure ….

Saunders-Newton: Data couple. I like data couple.

Macal: Okay. Well, there're data involved in it.

Saunders-Newton: Right.

Macal: I could see where economic, or some broader variables, would be available or could be measurable, but regarding the notion of the elites or the social aspects, what can you say about the data there, or how closely coupled is it potentially?

Saunders-Newton: In this particular community, ultimately you would never know. So the question is, how can you actually explore that space of possible data values? Can you ground the distributions so you can actually do something like a pliometric exploration of those values? Some of those you would just never know.

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But there are also really cool social science methodologies, such as unintrusive observation, where people have used these kinds of proxy variations that capture things, much of which comes from the nationalistic inquiry community in terms of how they actually approach this work. That can be explored, and so that has not really enjoyed some of the discussions about using ethnographies as a driving, because some of those insights may be helpful to actually capture ways of distributing — finding what the right distributions are to fit with that.

Ultimately, though, your point's really good. What you want is something that's totally connected with the data, which came up often, occurred consistently with this client and past clients. I say, anyway, it's just black magic. This doesn't exist. But it doesn't mean that the model can't provide you with some insights on how to behave, and that's our general next push: what is the ultimate goal of the modeling process?

Macal: I have a comment. Regarding your last slide and your reference to J. Forrester, which you know I'm very sympathetic to. It was brought up earlier in Epstein's talk that some of the epidemiology models they're working with are at some level agent-based models, but at a larger scale they can be kicked up into differential equation models and make that transition. So these may be potentially complementary approaches.

Saunders-Newton: I think that's true. As a person who's actually stored … methods (most of my time was in methodologies), I actually think there are many roles: it's about finding the right use of the twos, that is, have twos where you can actually use two or three at the same time on the same problem, methodologically speaking.

Ruby: All right. Thank you very much.

Knowledge Swarms: Generating Emergent Social Structure in Dynamic Environments

Ruby: Next, we have Robert Reynolds with "Knowledge Swarms: Generating Emergent Social Structure in Dynamic Environments."

Reynolds: This work was done in conjunction with Bin Peng, who's just finished up her Ph.D. at Wayne State. I'm affiliated with the Computer Science Department. Xiangdong Che did some of the recent programming, and also the Museum of Anthropology, University of Michigan — that's where Kent Flannery is. I do a lot of work with Kent. So it's a great follow-up to this talk. In fact, if you have the CD-ROM of Agent 2003, I have an operationalization of his model at a higher level of agency; not at the detailed level, but basically at the level of a site, so it's a nice tie-in. Obviously, they read these papers. So my perspective is from the perspective of AI and knowledge systems, and I'm interested in the emergence of social intelligence and socially motivated problem solving.

[Presentation]

Ruby: Thank you very much. Do we have any questions?

Mengziao Zhu: Mengziao Zhu from University of Illinois, Urbana-Champaign. I really enjoyed your research and your talk, and I have read about your former research. From your presentation today, I have several questions for you.

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First, do you use the homogenous agents in simulations? If you use the homogenous ones, what do you think is the mechanism for them to converge to the certain roles? Is it just randomly decided? And second, you mentioned knowledge models and knowledge resources in your presentation several times. Are they something similar to the strategies or the roles that are used in the system by the agents to behave or react to the environment and the evolving process of the knowledge sources? Are they something similar to the learning process in the AI area?

Reynolds: Yes, in fact, each of the knowledge sources is being adjusted in terms of learning. The interesting thing about homogenous agents — in fact, what we did is to effectively remove the agents' individual memories and put all of their experiences or a subset of their experiences into the belief space, and so they are completely stripped-down agents. So your question is great. Why would a role emerge in an agent that has no memory? Well, it's because the knowledge swarms have a memory, and that the size of, for example, the knowledge swarms on the roulette wheel is going to determine how frequently it's going to be used. For example, if you have one knowledge source that dominates everything else, then every time you spin the wheel for an agent, you'd get that knowledge source. So you'd get that one role coming back, even though the individual has no memory. It's an interesting way of looking at things, rather than starting at the level of the individual, starting at the level of their shared cognition and seeing how far you can go with that.

This takes us back to the notion of generative sufficiency. In fact, you can generate swarms at the individual level, even though individuals don't have any information about their past. It says something about the power of knowledge and the power of learning in directing the behavior of groups.

Ruby: I think we have time for one more question.

Ventkatesh Mysore: Ventkatesh Mysore from New York University. I have a question and a comment. Could you put your approach in the perspective of AI and mission learning techniques like descent and similar….

Reynolds: Well, the techniques that I use from traditional AI would be genetic algorithms — evolutionary computation. Certainly, we do inductive learning, and we have, but not in this example, used decision trees, and we use somatic networks. If it's available in AI, we can use it and represent it. Here, we go with some very simple inductive learning techniques and basically evolutionary computation.

Mysore: My comment is completely unrelated to the question. It has to do with an interesting example in biology that you might be able to exploit. It's called bacterial chemotaxis. If you have foot sores, the bacteria migrate toward the foot sores, so they have simple local computational routes that they use the chemical gradient to guide their motion toward the foot sores, and once in a while, they do a random tumbling to venture to a new direction. Maybe that is something you might be able to model.

Reynolds: Yes. Thanks. Sounds great, thank you.

Ruby: All right. Great.

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Adversarial Analysis of Evolutionary Models and Multi-agent Systems (Toward Theoretical Foundations for Generative Social Sciences)

Ruby: Next, Gabriel Istrate will present "Robustness of Evolutionary Models and Multi-agent Simulations to Adversarial Scheduling."

Gabriel Istrate: Thank you. So, adversarial analysis of evolutionary models and multi-agent systems: I bet that at this hour this doesn't mean a lot to you. As we've seen, one of the main themes of the conference is the generative approach to social sciences. In the words of Josh, if you didn't grow it, you didn't explain it or it's more complicated.

[Presentation]

Ruby: Thank you very much. Are there any questions?

Bryson This isn't really a question. It's just a comment on your last slide. One of the things I really liked about Axtell's paper, "Why Agents?," is that he brought out the point that sometimes it's easier to work with agent-based modeling just because it's intuitive. And while it's probably worth getting some analysis at some point, I don't necessarily think it has to be the first approach. If you have multiple approaches, you should possibly go with the one you're most comfortable and competent at.

Istrate: I totally agree. As I said, I do that for a living.

Xinrong Lei: My name is Xinrong Lei. If there is a simulation, I don't know if the results are different because of the initial situation or because of the randomness of the schedule. In this case, according to your suggestion, should I first adjust the randomness of the schedule, or should I eliminate the influence of initial situation? Thanks.

Istrate: I think both are important. I don't know if there is any single answer to that. I wasn't trying to make the point that you should try to attempt what I did here. I just wanted to have a very modest point, which is, you wouldn't expect, given that you could talk about any kind of schedule, to have any sort of mathematical result, and to my surprise that was not the case.

Michael North: Following up on that point, I'm interested in what you did here and, particularly, how it might impact the agent modeling toolkits and things like that, because obviously scheduling is a big issue there. What do you think the prospects are for a more generalized form? The things you did are very interesting, but there's a broader question of developing or maintaining a toolkit. How would you adjust that so it could take these results into account?

Istrate: It was mentioned yesterday that there is an approach called model checking in the formal verification educational literature that basically specifies scenarios as temporologic formulas and schedulers as automata. One problem with that type of approach as applied to the agent literature is that it's almost like looking for contra-examples. Some recent literature has dealt with model checking for mark of chains and versions of it, and that seems more applicable to agent simulations. That's precisely the long-term goal that I was alluding to. Basically, that's kind of the root.

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North: If there are other questions, I could follow up while we are waiting.

Macal: I've got questions.

North: Yes.

Macal: If I could just resummarize: the problem you're looking into is one in which the order of the choices of the agents is based on some strategic notion of interaction and a calculation on the part of the agents — "who goes next?" — based on some kind of Nash equilibrium or maximizing concept of utility, or at least an incremental improvement of utility for an agent, given its position. Some strategies could be adaptive in the sense that they're dependent on the state that the agents find themselves in. Others are not adaptive. They're independent of the state, maybe as a mark-off situation or whatever. So if that's a correct characterization, are you suggesting that agents can solve this complex selection problem, or in the instance of choosing which to move next, perhaps there's even a notion of bounded rationality that has to operate just to make the problem solvable given the agent perspective? Could you comment on that?

Istrate: Basically, I took apart one part of the dynamics and varied it. I tried to understand what is it in that part that makes the result hold for the random case and that could provide, for instance, if you want to talk about evolution, emergence of norms. Things like transmission via some sort of random walk mechanism are much more plausible than, "I'm just going to decide to update my strategy." So it was very modest in that sense, and I'm certainly not suggesting that agents could do that.

Macal: Okay.

North: Following up on the previous point, ideally, you'd want to find the one counterexample, the one bad event if you're presented with a scheduling problem like this. But even that could be, and I think is, extremely difficult given a complex problem. But is it possible, then, to consider general robustness, and so instead of one bad event, build this model and be faced with many, many bad events, or a large percentage of events being bad in some sense? Do you think that might weaken the problem and, therefore, make it more solid?

Istrate: I don't really have a good intuition about that, so I also started looking at what happens if I take one result and change the graph topology a bit. It's basically a beginning, an avenue, that could be investigated and not much more than that. I don't claim there is any sort of general guidance or ….

North: No, I think it's excellent work. I'm just interested in the implications

Understanding Insurgency by Using Agent-based Computational Experimentation: Case Study of Indonesia

Ruby: Okay. Now we have Alok Chaturvedi from Purdue University, who will talk about "Understanding Insurgency Using Agent-based Computational Experimentation."

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Alok Chaturvedi: Thank you. I'll try to go very quickly. I'm the last speaker, so I won't hold you for long. I'm going to talk about a project that we have just started working on for the Joint Forces Command, and we will be using this for urban resolve, so we'll be supporting them in July.

[Presentation]

Unidentified Speaker: Are the data any good?

Chaturvedi: Once you have a common framework, you can do that. That's why I said, that continuous validation is the key. What we did was model 12 months before the tsunami, and then we continuously validated after the tsunami. The results are pretty amazing because if you — I'll come to that in a second.

[Presentation Continues]

Ruby: All right. Thank you very much. Are there questions?

Steven Wilcox: I noticed that you have hierarchal agents, and some of what you're talking about sounds like what is called generative practice theory by Gregg Courand and Michael Fehling. Do you know what that is, and do you see the resemblance?

Chaturvedi: We don't have a hierarchical agent *per se*. Okay? So many of those behaviors are emergent behaviors. It may look like we have a hierarchical agent, but we have population, and then it is all about who is communicating with whom. So what we have is a gigantic publish-and-subscribe architecture, if you may call it that, so that people are communicating. So we ask how does communication emerge as those things that are imposed by a certain structure in the society, so the organizations are formed, organizations are disbanded, institutions are formed, which are much, but, you know, like this is a fully integrated emergent type of society.

Ruby: The slides that you displayed, which I assume showed what the model does, were very complex. I'm wondering if you could, in more straightforward terms, talk briefly about the inputs that are creating or fueling the parameters of the model. What is the output, and what does this output mean? Is the output some sort of risk of insurgency or violence? And finally, what is it that your model does that one might not be able to do in following the media of, say, Indonesia in this given time period?

Chaturvedi: There are several things that we do, which models typically are going to do. Intervention is a big thing for us because we are working with the Department of Defense, and they want to take certain actions. It's not just Department of Defense, but it is interagency — coordination groups, as they call it — say the State Department or USAID. They're taking DIME actions, Diplomatic Information, Military and Economic. So those are the actions they're taking. The way we model is an end-sided game.

We've got what we call "glow," which is the coalition. We model red, which are the bad guys, so to speak. We've got green, which is the local government, and we have gray, which is our country axis — all the other countries in the region. All of them are interacting. We have a

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dynamic environment that is continuously running. They are all doing their own thing. The citizens are doing their own thing, and the organizations are doing their own thing.

So what do we observe? In this particular case, we're looking at propensity to do violence or to join the insurgency, or the intent to rebel, as we call it. But in different situations, we've got a full economic engine that is running, so it is generating all the economy, doing production, consumption and all those things — imports, exports — so you can look at that.

Now, if you're doing certain interventive strategies … let's say you have an economic sanction or you have a blockade and other things. It is going to reflect what is going on in the global economy. If there is an insurgency, one of the things that we are trying to model is what would happen if there is a major incident in Iraq. How is that communicated?

One of the critical things that we have is a story-telling model. We might have the same incidents observed by four different parties, and there are four different story lines, which we have. These story lines are going to their own networks, to their own subscribers, and then they are generating different types of behaviors and emotions. Again, that is going to feed back into the system. Now, you're going to observe what is going on in the political model, what is going on in the military model or economic or social and others so you can start observing. You can observe just about anything. You can look at what is going on in any infrastructure that was blown up, for example. What does it do? What happened yesterday, you know, the whole blackout? What impact did it have on society?

Ruby: Because you're pulling in data from the real world?

Chaturvedi: Yes.

Ruby: Or do you have an isolated universe that is somehow parallel to the ….

Chaturvedi: It is a parallel universe from the real world. We are building tools by which we are mining the real world, all the blogs and newspapers and others, and we put the data back into the system.

Saunders-Newton: I'll be so bold and presumptuous to expand upon Alok's response. Part of what drives this effort and a number of other efforts is this whole issue around effects-based operations. So the 7¢ story is basically about being consequent-aware. If you can actually think about the choice between using military force and using development dollars versus using diplomacy and using whatever of the national strengths that are available to you, can you model that to think about the possible consequences so you can think about second, third, or *n*'th order effects? That's the real issue about using simulations, so that's one of the outputs with a number of these efforts. Is it, and, again, Alok has this particular one, but there are a couple of others that are supporting some of these activities with this….

Reginald Tucker-Seeley: Reginald Tucker-Seeley from the Harvard School of Public Health, as well as the Dana-Farber Cancer Institute, so I've really enjoyed your cancer example. You're right; we're trying to go back and figure out what determinants yield the outcome that we're evaluating. It's a very difficult process.

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You mentioned that the data sources were good in regard to validation. One thing that we note is that it's difficult to compare data from different sources across different scales, so could you possibly talk about how good the data are and the comparability of the data from several sources across different scales for your model?

Chaturvedi: One of the important things is how to have a consistent framework, so obviously we're looking at economics — political science, international relations. You have all these different areas, so people are describing things in very different ways. You have to come up with a common framework on how to model these things. That is one of the things we have done. And in going back to different skills, so you know, we have heard a lot of talk about ontology.

So let's say, there is a fire in this room. Over there is a door for all of us. Just consider that we are all agent simulations. For us, that door is for escaping, but the moment we open the door … say it is a totally different meaning for the fire model. The fire model has more oxygen, so the fire is getting more fuel to burn faster, right? It is all about how you translate the ontologies between different things, and especially, in this case, we may be running into the second time scale, whereas the fire model may be running into the millisecond or even the microsecond time scale.

So the thing is, we have another project, which we call simulation bridge, that is a shared reality engine. The way we operate over there is like here: we all are talking and listening, and we are sharing some reality with each other. Okay, so we're not really sharing whatever we have going on outside this room. That is how we model all these complex simulations so that we are only sharing the realities that we need to share and everything else is done offline. That is how we do the multi-scaling problems.

Larry Kuznar: Yes. It's an impressive compilation of many different kinds of information from many different parts of the world with different social systems, and I can appreciate that one of the problems you must have run into is having certain systems where it was hard, perhaps, for the base model to predict. Related to that is that a lot of calibration had to be involved in building the model and in adjusting it to these different databases. How long did that take? I mean, what was the scope of this project?

Chaturvedi: It's a huge problem. In fact, we have been working with the Joint Forces Command for over two years, almost three years now. We started very small — a very small region with very high level actions. Then we took one country or one city and expanded that and added more actions, more nodes. Right now, as you can see, we've got 12 million agents that we are running. I think, to the best of our knowledge, it is at least one or two orders of magnitude better than most of the things out there. The reason for that is that we approach this whole thing from the computer science perspective first. The first thing that we did was look at a good architecture to deal with this complex problem, where we can take multiple disciplines so that we'll be able to map things into our environment and solve some of the more critical scaling problem.

So once we did that, we started adding more and more models. We got a social science model and physics-based models. We are integrating with a lot of attrition models like JASAF and JWARS and others that are already attrition models out there. We are linking with two other

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European models. One is Joanna and one is Eliance. One is a French system and one is the German system. But, again, I mean, you are absolutely right. For us, calibration is the key thing.

So we broke it down so that there are certain forward problems and there are certain inverse problems. Obviously, we said we are not going to try to solve those inverse problems, because, I mean, there would be a gazillion solutions to the same thing. Okay, so we said, "Let's solve these forward problems and let's calibrate at the inverse problems for our problem level." So we modeled at the individual level, and we calibrated at the population level. So once you have bound those problems, it is a lot easier to, again, match the results from the real world. So that's why continuous validation is our approach, and that is something that is working very well for us.

Ruby: All right. We actually have time for one more question.

Wilcox: What sort of mathematics or statistical methodology or economic methodology did you use to solve the inverse problems?

Chaturvedi: I am not saying we are solving the inverse problem. It is almost impossible to solve the inverse problem at this scale. Okay, it is absolutely impossible. It is intractable and there is no way trying — I mean, there is no reason trying to solve the inverse problem, okay?

So we are using statistics. We are using a whole bunch of different econometric matter to make sure that the synthetic data that we are getting and observe the data from the real world, and those are statistically — I mean, and solving all those T tests and other tests to show the results from there.

The other thing we are doing is that we are using bunches of different parametric and nonparametric methods to analyze the relationship going from actions to effects and from effects to actions because this is a pretty complex problem, and even making an attempt to solve the endless problem is futile. We can do that in smaller chunks, but not at the scale at which we are doing.

Ruby: All right. Thank you very much, and thank you to all the panelists this afternoon.

Macal: I'd like to thank Keven Ruby from The University of Chicago for chairing that session. Thank you, Keven.

As we close out this Agent 2005 session, I'd like to give a few thanks and acknowledgements. I'd like to thank the administrative people that are the AV recorders and the Program Committee of the Agent 2005, including David Sallach for computational social theory and Michael North for methods, toolkits, and more. I'd like to thank Michael North again for organizing and conducting the Repast training course earlier in the week.

Finally, I'd like to thank you all very much for your contributions, your active support, your attention, and your contributions to forwarding computational social science in the form of theory applications and toolkits and methods. We hope to see you next year.